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Cosmic Ray Changes and Total North Atlantic Cyclonic Activities

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Recently it was shown [1], [2] that there exist some interconnections between the cosmic ray changes in the days, preceding the appearance of the hurricanes over the North Atlantic Ocean. Here these interconnections are investigated on the basis of all recorded hurricanes and tropical storms in the 55 years (1950 – 2004). The entire cyclonic process in every year was examined simultaneously with the corresponding changes in cosmic ray intensity, solar activity and global magnetic field disturbances. Specific Forbush cosmic ray decreases and magnetic oscillations was noticed before the start of practically every cyclonic activity. This research could help the possibility of an early hurricane forecast.

1. Introduction

Connections between changes of Cosmic Ray (CR) intensity and space weather were carefully investigated [3]. From the other side, a link between the space weather and meteorological weather was established not only for the last century [4], but also for several centuries ago [5]. Lately some indications appeared that some purely meteorological processes in the terrestrial atmosphere are connected with the changes in CR intensity, and influenced by solar activity, and magnetosphere variations [6]. Because all of that, we tried to examine the eventual interference between the CR intensity and one of the most powerful bursts of the meteorological weather – the North Atlantic Hurricanes.

Here we analyzed data for all recorded North Atlantic Hurricanes and Tropical Storms (C) in the last 54 years (1951-2004), together with corresponding data for: CR intensity variation, Geomagnetic index KP, and Sunspot (SS) numbers in the same 54 year interval. **Still without specifying any mechanism of interdependence between these parameters and the cyclone formation**, we are trying to find a well-expressed parallel between them and possibly indications of specific persistent changes in some of these parameters, preceding the cyclone appearance. That could help the efforts for earlier and better hurricane forecast.

2. Data

A complete table of all **North Atlantic Cyclones** was made comparing many sets of available web data. For every one of them, its maximum sustained Rotational Wind Velocity (**V**) was tabulated in 6-hour intervals. In that form, this basic table includes **16752** 6-hour cyclone positions for **574** tracked cyclones, recorded in **54-year** (1951 – 2004) and arranged chronologically. Tropical Depressions (cases when **V < 63** km/h) were not included.

From the **CR data,** available on the Web, we chose the hourly Neutron Monitor Data received on Climax CR station, (39.37N; 106.18W; alt. 3400 m and 2.97 GeV Cut-Off rigidity). It appeared, that they covered the period 1951 - 2004 with negligible instrumental changes, low percentage of missing data and wonderful stability. For the whole period of 54-years (19724 days) only 399 days are without any data, or only 2.02 %. That is a 97.98 % of effective measured CR intensity. We carefully interpolated the missing data.

We chose the **geomagnetic data**, presented by NOAA, Boulder Colorado, USA, in a parallel table for KP – the planetary geomagnetic index and SS – the International Sunspot Number.

3. Data elaboration.

In our earlier works we studied the behaviour of Cosmic Ray Intensity and other geomagnetic parameters prior the appearance of every separate hurricane. Here we used another approach, calculating:

$$E_n(t)= [V_n (t)]^2 . \qquad (1)$$

$E_n(t)$ was defined as parameter, presenting the energy of the cyclone n in the moment t rather well. If N cyclones are overlapped in a moment t, then the total cyclonic energy distributed over the Atlantic Ocean is taken as:

$$E_1(t) + E_2(t) +\ldots + E_{n=N}(t) = E(t). \qquad (2)$$

Summing the 4 adjacent 6-hour intervals, we receive the corresponding daily energy E(d), where d varies from 1 to 365/366 for every year/leap year. Combining E(d) for all investigated 54 years, we create a table E(d,y)(366 x 54). Summing by rows, we obtained interesting energy distributions: the average E(d), presented on (Fig. 1.)

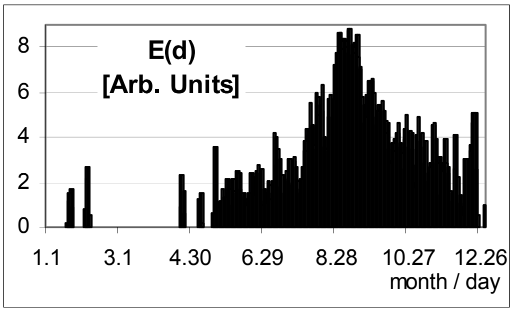

Figure 1. Average E(d) distribution.

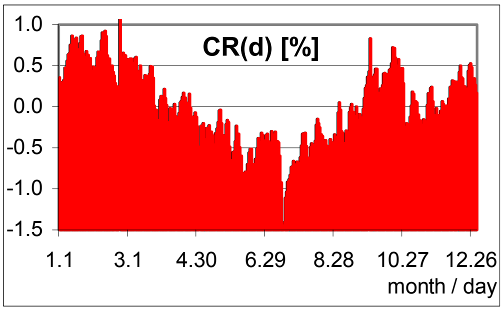

Figure 2. Average CR(d) intensity distribution.

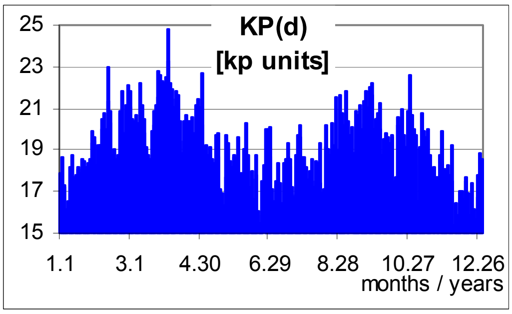

Figure 3. Average AP(d) distribution.

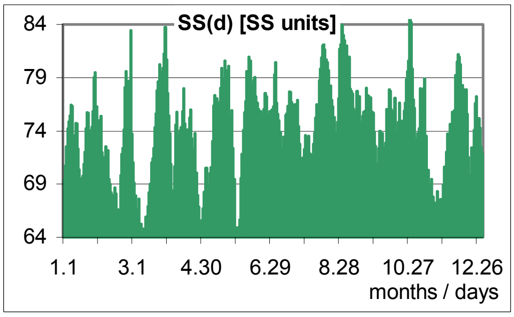

Figure 4. Average SS(d) distribution.

The same procedure was applied for the CR, KP and SS data. The results are depicted correspondingly on Fig. 2., Fig. 3., and Fig. 4. As it is known, the cyclonic activity is well expressed in August, September and October. It is insignificant in July and November and practically zero in the other months of the year. The same distribution could be observed for E(d) on Fig. 1. It appears that something like gigantic Forbush for these 54 years was strongly concentrated around July 14. (Bastille Day). KP(d) presents a double hump yearly distribution with a minimums 2 weeks earlier - around the beginning June. SS(d) shows one of its sharpest minimums one more month earlier - around the beginning May.

To establish a possible similarity, or parallel changes between E(d) and either one of the distributions: CR(d), KP(d), SS(d) we correlated them only in two time intervals, preceding the maximum of the cyclonic activity: the 100-day interval between July 11 and October 19, as well as in 40-day interval between July 31 and September 9. Then we smoothed all these distribution with a step of 27 and correlated them again in the same intervals. The obtained correlation coefficients were systemized on Table 1.

Table 1. Correlation Coefficients between E and CR, KP, SS

			direct			smoothed		
From	Till	Days	CR	KP	SS	CR	KP	SS
11.Jul	19.Oct	100	0.38+_0.04	0.50+_0.06	0.42+_0.07	0.69+_0.16	0.91+_0.04	0.64+_0.20
31.Jul	9.Sep	40	0.41+_0.13	0.62+_0.08	0.61+_0.06	0.93+_0.25	0.92+_0.08	0.98+_0.20

Obviously the correlation coefficients rose after smoothing. But their values showed very a well expressed parallel in this part of the year, when the cyclonic activity increases strongly.

A careful examination of the shown graphs disclosed an interesting secondary modulation, overlapping the basic change of all curves. We filtered them suitably, suppressed the main extremes and extracted the remainder waves. They are shown on Fig. 5.

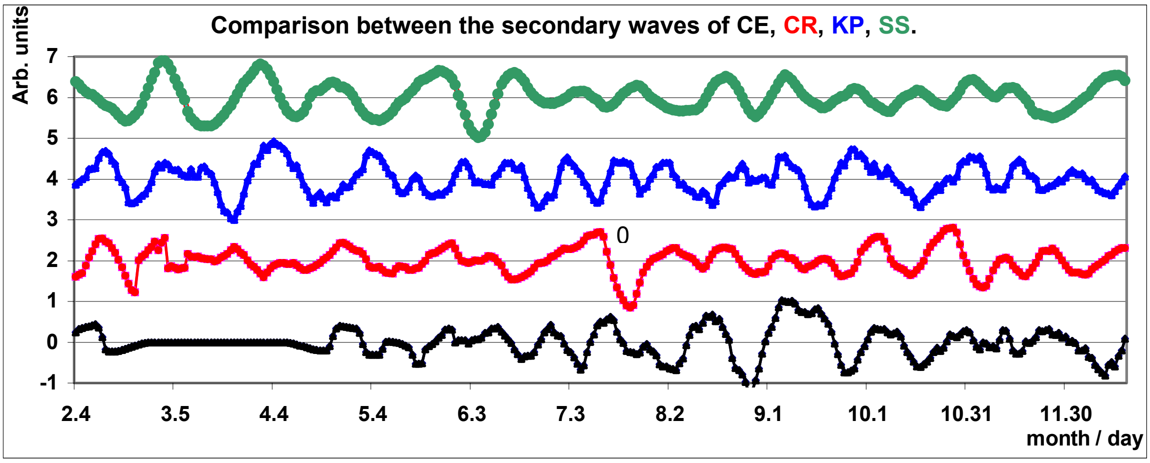

Figure 5. Extracted secondary waves over the averaged yearly distributions of CE, CR, KP, SS.

For the first time such a wave, similar to that extracted of the yearly distributions of KP, SS and CR is found overlapped over the cyclonic energy curve. The periods of these waves are very close. Their average values are around 20–25 days. The correlations between these waves are strongly reduced, because the instable phases. Nevertheless, their similarity could suggest a common source of influence.

All this is over a long period of time and with a vast amount of basic data. To be sure of the continuity of these results, we divided in 5 groups all considered years, depending on the value of their yearly averaged $E_{av}(y)$. The most cyclonically active 10 years were included in Group 1 – the quietest 14 years - in Group 5. The average yearly distributions of $E_{av}(d, g)$ [g=1,2,3,4,5] for these 5 groups are depicted on Fig.6. It could be noticed that with the decrease of the averaged energy, the peak around September 10 becomes flatter and less pronounce. Correspondingly the calculated changes in groups for CR, KP and SS sustained their average shape.

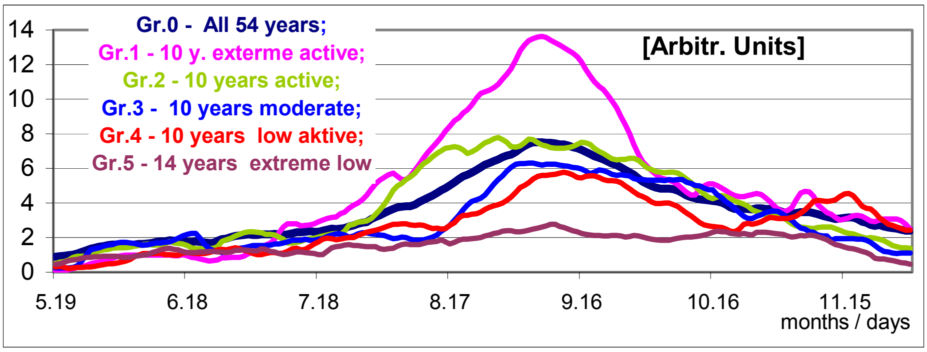

Figure. 6. Yearly cyclonic Energy distributions in 5 Groups.

4. Conclusion.

For the first time the rotational energy **E~V²** at a recorded point and time of the cyclonic development is used as a basic additive cyclonic parameter. That allows defining the total cyclonic energy **E(d)** in the day **d** over the Atlantic Ocean.

The results obtained here showed unambiguously that in the months, preceding the cyclonic energy maximum, there are parallels in the total increase of that energy E and the changes of CR intensity, geomagnetic planetary disturbances KP and Sunspots SS variations.

Their similarity is emphasized with the presence of a secondary practically equal overlapped wave.

From the other side, the enormous difference of the energy engaged in these processes and the reduced correlation between them in the other parts of the year assume complicated interconnections. The coincidence of the yearly minimum of CR and KP in the middle July with the averaged start of cyclonic development is promising for an earlier hurricane forecast.

5. Acknowledgements

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